HANDOUT #4

COMPETING INFLOW AND OUTFLOW HYPOTHESES

(Revised 2/2/09—GG notes 2/4/09)

The BDCP X2/Outflow group developed the following list of hypotheses to identify the range of water project operations controlling outflow that may be necessary to restore covered species. The X2/Outflow group did not attempt to evaluate the validity of any of these hypotheses and did not intend to imply, through the order or description of hypotheses below, that any hypotheses was more valid then others. The sole purpose of articulating these hypotheses was to guide BDCP water management scenario planning by identifying the range of water project operations that may be necessary to achieve recovery of covered species.

1. ***Spring X2 Not Limiting:***
   The X2/Abundance correlation is weaker then other correlations.
   Abundance, particularly for some species, may correlate with other factors such as ammonia or temperature better then they correlate with X2

   Operational implications: Address other factors and relax X2 requirements. Point of information on X2: the standard is based on the approximate X2 levels for a 1967-72 (+/-) level of development; other levels were evaluated and could be again. The historical range is wide, and the pattern in the 1960's was heavily influenced by upstream reservoir storage and upstream diversions in the Feb-June period. More recent periods are influenced by the management to the levels in the standard.

2. ***Spring X2/Abundance Correlations are Still Important.***
   The existing correlation between X2 and abundance may be weaker then the historical X2/abundance correlations, but X2 is still important when controlled for all other factors. The existence of a strong correlation for past periods show there is a link between X2 and abundance. The weakness in the current correlation is due to other factors stressing covered species abundance. Covered species are endangered. Reducing one stressor does not justify reducing outflow requirements.

   Operational implications: Address other factors and maintain X2 requirements.

3. ***Spring X2/Abundance Correlation Not Continuous***
   Westward X2 only has substantial benefits for covered species when flows are over 30-50 k but very limited or no benefits when flows fall below these high thresholds.

   Operational implications: Manage outflows at or above 30k-50k in wetter years when these high flows are achievable. In drier years, do not attempt to increase outflow (decrease X2) because it requires a lot of water to make a relatively small difference in location of X2, potentially increases risk of negative upstream reservoir effects, and does not yield any appreciable difference in species abundance.

Problem: Short lived species like Longfin Smelt are particularly vulnerable to multiple years when X2 will be low. If this hypothesis is incorrect, multiple years of low X2 in drought periods could lead to extinction.

4. ***Spring X2/Abundance Correlation is continuous:***
Any westward movement of X2 results in increases in abundance of most covered species. X2 is particularly important in dry periods when species numbers are low.

Operational implications: Increase outflows (decrease X2) in all years with particular emphasis on dry year sequences when covered species may need an extra boost.

Problem: Increased outflow, particularly in dry years, reduces water supply for other beneficial uses such as temperature control below reservoirs, increased flows in other periods or locations, and consumptive uses. (see above note on X2 development in the current standard).

5. ***Fall X2***
Covered species abundance is negatively correlated with fall X2 (lower X2 equals more fish). (Fall salinity (and therefore X2) are also correlated with abundance and extent of Corbula, which may be important. This should figure into this analysis as well.)

Operational implications: Increase fall outflow to decrease fall X2.

Problem: Increased outflow, particularly in dry years, reduces water supply for other beneficial uses such as temperature control below reservoirs, increased flows in other periods or locations, and consumptive uses.

6. ***Variable salinity:***
Fluctuating salinity will create a competitive advantage for covered species over exotic species that compete with or prey on covered species.

Operational implication: Maintain or increase outflow in the spring relative to the existing standards and decrease summer and fall outflow relative to the existing standard.

Problem: Conflicts with fall X2 hypotheses. The basis for this is undocumented. Originally, it was proposed by the PPIC authors, particularly Moyle – (http://www.science.calwater.ca.gov/events/workshops/workshop_variable.html) to flood the interior of the delta with salinity levels that would kill Egeria and Corbicula. The PPIC authors assumed this is what happened in the good old days, but had misinterpreted the data. The DBCP studies have already shown that zero outflow for 3 months does not even get the required salinity levels to kill these critters past Antioch, and Kimmerer and Thompson in the same workshop spelled out the hazards of trying this. A basis for this and the required salinity levels (timing,

duration, salinity level) have not been developed nor has the expected outcome, something that would be required. Among the issues are the undesirable effects on Corbula (enhances their extent, density and growth), and the reduction in habitat for other species, including delta smelt, including pushing them into the hotter environment in the interior channels as salinity moves in.

7. ***Entrainment***

Entrainment is an important mechanism for the X2 correlation. Higher, more easterly X2, results in greater mortality.

Operational implication: Move the point of diversion and install screens to decrease entrainment.

8. ***Habitat Area:***

Low Salinity Habitat Volume/Area is the primary mechanism for the X2 Correlation. Increasing the area and or volume of open water habitat (or alternatively tidal marsh) eastward of existing low salinity habitat zone through flooding reclaimed lands will change the X2/species abundance correlation and will therefore allow eastward movement of X2 without any adverse impact on covered species abundance.

Operational implications: Relax X2 standards for all year once restored habitat is created and functioning in accordance with hypothesis. Or alternatively, increase and manage X2 to maximize low salinity zone habitat in Suisun Bay.

Problem: Creating new open water habitat (flooding west Delta islands) is complicated and risky. Is there someway to test this hypothesis short of large-scale, open water habitat restoration? Creating tidal marsh is easier, but even less certain to benefit pelagic species. Restoring tidal marsh in the vicinity of Suisun bay may be more effective then restoration further east, because seasonally brackish conditions should limit populations of exotic species. See discussion above; temperature needs to be considered as well as other habitat parameters. The interior is simply at higher temperature in the warm season and could be detrimental to sensitive species like delta smelt.

9. ***Floodplain Inundation***

Inundated floodplain habitat in the late winter and spring is the primary mechanism for the X2 correlation.

Operational Implications: Notch weirs, set-back levees, and/or manage reservoir releases to increase the frequency flows that will inundate floodplains and relax X2 if consistent with floodplain restoration.

Problem: Increasing late winter and spring releases may not be consistent with meeting water supply demands which are higher in the summer and fall. Although, there is broad consensus that inundating floodplain habitat would benefit some

covered species, it may not benefit all covered species. Lack of correlation between zooplankton and X2 suggests that food supply inputs from floodplains are probably not the mechanism for species such as Longfin Smelt.

10. Inflow

High inflows in the late winter and spring are the primary mechanism for the X2 correlation. High inflows provide the following benefits to covered species:

- Inundate flood bypasses for rearing and spawning.
- Improve passage conditions in Steamboat and Sutter Sloughs
- Improve rearing habitat along entire river reach.
- Facilitate downstream passage along entire river.
- Flush food supplies from rivers into Delta
- Reduce temperatures in shoulder months of late spring
- Increased turbidity either through erosion or phytoplankton production in the flood bypasses.
- High San Joaquin inflows reduce entrainment in South Delta
- Reduced temperatures in a broader area (there are now 2 published papers documenting the importance of advection in the delta in establishing temperature)

Operational Implications: Manage reservoirs to increase and or prolong late winter and spring high flow hydrograph and relax spring X2 if consistent with increased inflows.

Problem: Increasing late winter and spring releases may not be consistent with meeting water supply demands which are higher in the summer and fall resulting in trade-offs between ecological benefits and water supply. Increased water dedicated to spring outflow and not available for export or other uses will reduce water supply for other beneficial uses such as temperature control below reservoirs, increased flows in other periods or locations.